INDOOR AIR QUALITY ASSESSMENT

Frank H. Freedman Elementary School
90 Cherokee Drive
Springfield, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Lynn Rose of the Western Massachusetts Coalition for Occupational Safety and Health (MassCOSH), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Frank H. Freedman Elementary School, 90 Cherokee Drive, Springfield, Massachusetts. Reports of asthma exacerbation in several individuals prompted this request. On September 26, 2001, a visit was made to this school by Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment.

The school is a single-story, panel-clad building that was constructed in 1961. The school contains general classrooms, auditorium and administrative offices. Windows are openable throughout the school.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak ™, IAQ Monitor Model 8551.

Results

The school has a student population of 350 and a staff of approximately 20. Tests were taken during normal operations at the school and results appear in Tables 1-2.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in three of sixteen areas surveyed, indicating adequate ventilation in most areas of the school. Please note however, that a number of classrooms had open windows or low occupancy, which can greatly reduce carbon dioxide levels. Carbon dioxide levels in the building would be expected to increase above comfort levels during winter months when windows are closed, due to the configuration and condition of the ventilation system.

Fresh air in classrooms is supplied by a mechanical unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (see Picture 1) and return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and a heating coil, and is then expelled from the univent by motorized fans through fresh air diffusers (see Figure 1). Univents were operating in all but three classrooms surveyed during the assessment. Obstructions to airflow, such as objects stored on or in front of univents, were observed in a number of classrooms. In order for univents to function as designed, fresh air diffusers and return vents must be unblocked and remain free of obstructions. Importantly, these units must be activated and allowed to operate during classroom occupation.

Exhaust ventilation is provided by a mechanical exhaust system. The exhaust vents are located in the upper portions of coat closets in classrooms. Classroom air is drawn through a space beneath the closet door and exits via the exhaust vent at the top of the closet (see Picture 2). This design allows for the vents to be easily blocked by stored materials on shelves beneath the exhaust vent. In a number of classrooms, vents were blocked with boxes, cartons, books and other obstructions.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this occurs a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health

Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings ranged from 73^{o} F to 77^{o} F, which were within the BEHA recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity was measured in a range of 35 to 43 percent, which was close to the BEHA recommended comfort range. The BEHA recommends that indoor relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. It is important to note however, that relative humidity measured indoors in a number of classrooms exceeded outdoor measurements (range +2-7 percent). This increase in relative humidity can indicate that the exhaust system is not operating sufficiently to remove normal indoor air pollutants (e.g., water vapor from respiration). Moisture removal is important since the sensation of heat conditions increases as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). As indoor temperature rises, the addition of more relative humidity will make occupants feel hotter. If moisture is removed, the comfort of the individuals is increased. Removal of moisture from the air, however, can have some negative effects. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several conditions indicate that water penetration through exterior walls, doors and window frames is occurring. Caulking around windows was crumbling/damaged throughout the building indicating that water seals are no longer intact. Water penetration through window frames can lead to mold growth under certain conditions. Replacement of caulking and repair of window leaks are necessary to prevent water penetration.

The exterior wall system of the building consists of wooden frames that hold paneling, door and window frames (see Picture 3). In a number of areas, this frame system had peeling or eroded paint and panel sealant, which can allow for moisture to penetrate the wood during wet weather. These conditions appear to have caused some of these frames to rot on the southern wall of the building. In one instance, damage to the framing system has resulted in a section of exterior wall cladding to slide from its mooring (see Pictures 4 and 4A). If water is saturating the frame material, water penetration into the interior wall cavity is likely through panel/frame seams (see Picture 5). Another source of water penetration through the exterior wall system is exterior doors. Water damage around doorframes was observed in a number of classrooms. Water penetrating into the wall cavities can serve to moisten building materials or debris, which can then lead to microbial growth in the wall cavity.

The interior of several univents was examined. As univent motors operate, the fan chamber depressurizes, which draws air from the classroom into the cabinet through the return vent. If holes exist in the fan chamber, air may also be drawn from the chambers containing univent controls and utility pipes. If holes into the exterior wall cavity exist in the controls and utility pipe chambers, then air debris can be drawn into the fans and distributed into classrooms. Each univent examined had holes in the fan chamber walls as well as opening into the exterior wall cavity (see Picture 6) from the controls and utility pipe chambers. In this condition, air and pollutants can be drawn into univent fans and distributed into classrooms.

A potential source of microbial growth exists within the univent controls and utility pipe chambers. An active water leak was noted in pipes for a univent (see Picture 7), which then dripped onto the floor of the cabinet. Univent controls and utility pipe chambers examined had a heavy coating of dust, dirt and other debris. In one univent, water spattering on the floor of the univent utility pipe chamber formed a distinct pattern (see Picture 8). Moisture combined with accumulated debris can provide a medium for microbial growth. If microbial growth occurs, spores and other related materials can then be drawn into univent fans.

Several classrooms contained a number of plants. Plant soil and drip pans can serve as a source of mold growth. Plants should also be located away from univents and exhaust ventilation to prevent aerosolization of dirt, pollen or mold.

Located outside room 13 is a compost heap (Picture 9). This pile of debris is located in close proximity to the univent fresh air intake for this classroom. Composting is a controlled degradation of organic material by microorganism (US EPA, 1991). These microorganisms may include both bacteria and fungi. Microorganisms in the compost pile may be drawn into the univent and then distributed into this classroom.

Other Concerns

Of note is the use of different volatile organic compound (VOC) containing products in the building. Materials such as rubber cement, permanent markers, dry erase markers and liquid correction fluid were observed in a number of classrooms. These materials may contain volatile organic compounds, which can be irritating to the eyes, nose and throat and, in some cases, extremely flammable. Local exhaust ventilation should be utilized when these products are used. Under the Labeling of Hazardous Art Materials Act (LHAMA), art supplies containing hazardous materials that can cause chronic health effects must be labeled as required by federal law (USC, 1988). The use of art supplies containing hazardous materials that can cause chronic health effects should be limited to times when students are not present and only when adequate exhaust ventilation is available.

Accumulated chalk dust was noted in a number of classrooms. Chalk dust is a fine particulate, which can be easily aerosolized and is an eye and respiratory irritant.

Univents are installed with air filters that provide minimal filtration of particulates. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed in the univents. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by the univent by increased resistance (called pressure drop). Prior to any increase of filtration, each univent should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters.

Conclusions/Recommendations

The conditions noted at Frank H. Freedman Elementary School raise several issues. The combination of the ventilation system design and exterior wall system can have an adverse impact on indoor air quality. For these reasons a two-phase approach is required, consisting of immediate **(short-term)** measures to improve air quality at the school and **long-term** measures that will require planning and resources to adequately address overall indoor air quality concerns.

The following **short-term** measures should be considered for immediate implementation:

1. Remove the compost pile from close proximity to the fresh air intake. Removal should occur after school hours. Temporarily seal the fresh air intake with polyethylene plastic to prevent contamination during the removal.
2. Render holes in the fan cabinets airtight with a sealant compound.
3. Seal holes inside univents with rigid foil faced sheet material and water based high temperature and fiber reinforced mastic. Temporarily sealing the holes in this manner would prevent both air and moisture penetration into univents.
4. Clean accumulated debris from the interior of all univents.
5. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room and make univent repairs as needed. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
6. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed in the univents.
7. Acquire current Material Safety Data Sheets for all products that contain hazardous materials and are used within the building, including office supplies, in conformance with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (MGL, 1983).
8. Consider replacing art and school supplies containing materials that require labeling under the Labeling of Hazardous Art Materials Act (LHAMA) with water-based materials, to reduce VOCs in classrooms.

9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
10. Move plants away from univents in classrooms. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
11. Clean chalkboards and chalktrays regularly to prevent the build-up of excessive chalk dust.

The following **long-term measures** should be considered:

1. Consideration should be given to repairing or replacing the exterior wall system where the frames are materially degraded.
2. Repair leaks in the univent joints to prevent moisture build-up. Repairs may include replacing heat system components.
3. Removed damaged window caulking and reseal windows.

References

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Picture 1

Univent Fresh Air Intake

Picture 2

Exhaust Vent at the Top of the Closet

Picture 3

The Exterior Wall System of the Building Consists of Wooden Frames, Note Plywood

Picture 4

Damage to the Framing System Has Resulted In One Section of Exterior Wall Cladding to Slide From Its Mooring

Picture 4A

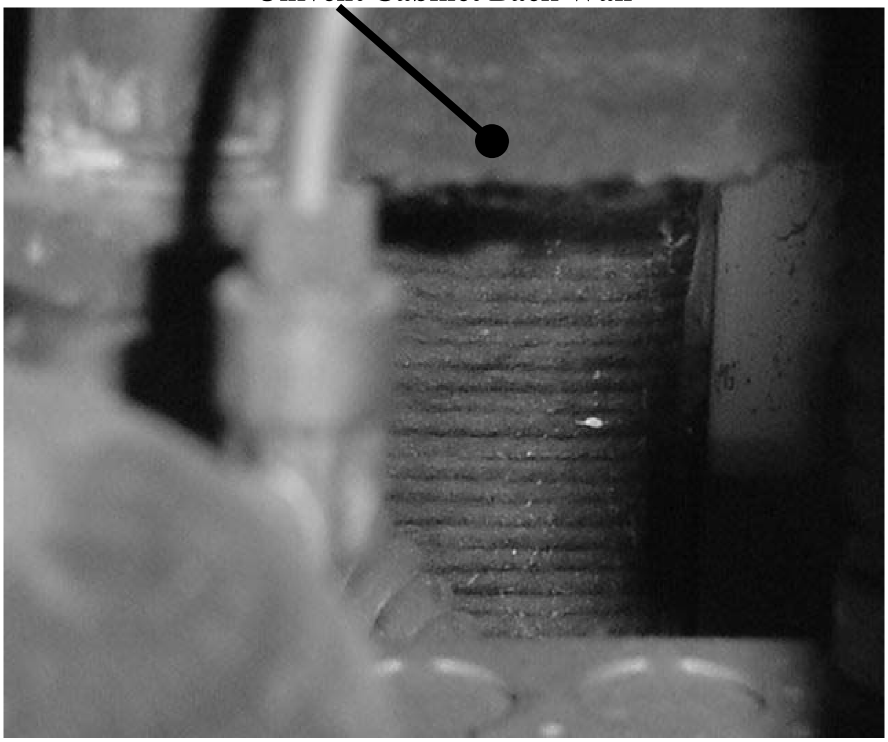
Base Of Sliding Panel in Picture 4, Note Decayed/Missing Frame at Base of Panel

Picture 5

Damaged Window Frame

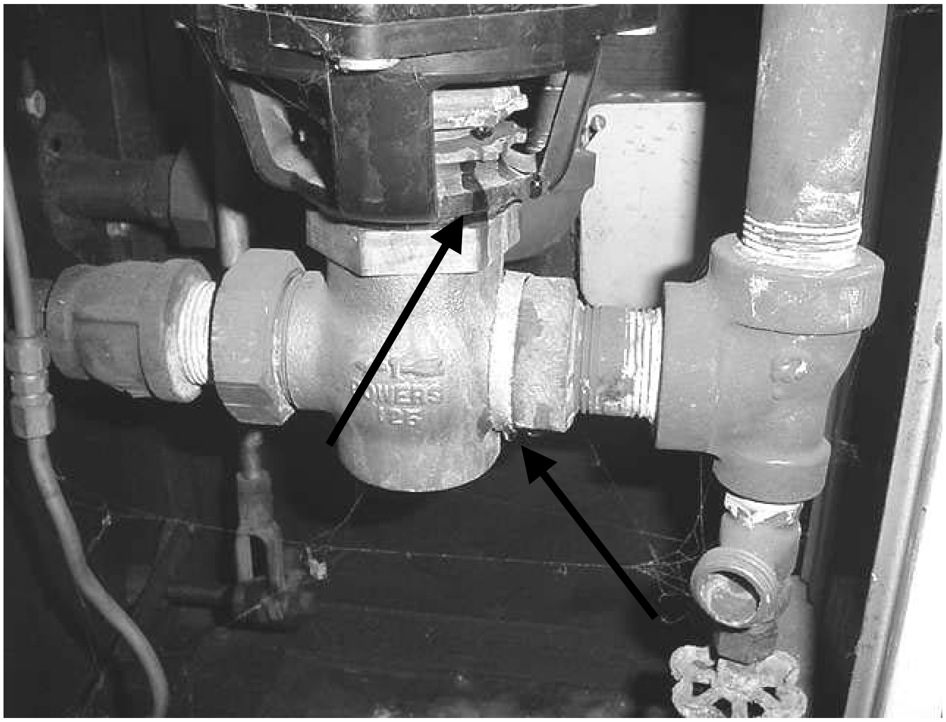
Picture 6

Univent Cabinet Back Wall



Hole In Back of Univent Open to the Exterior Wall Cavity

Picture 7



Active Water Leak Was Noted In Pipes for A Univent

Picture 8

Pattern Formed In Accumulated Materials on Floor of Univent Chambers by Dripping Water from Heating System

Picture 9

Compost Heap outside Room 13, Note Univent Fresh Air Intake

TABLE 1

Indoor Air Test Results – Freedman Elementary School, Springfield, MA – September 26, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Outside (Background)	346	66	36					
Room 8	608	75	38	21	Yes	Yes	Yes	Sanford® king-size permanent marker, window open
Room 9	479	75	35	1	Yes	Yes	Yes	Permanent magic marker
Room 10	566	76	38	9	Yes	Yes	Yes	Exhaust off, chalk dust, rubber cement, magic marker, door open
Auditorium/Stage	847	77	41	2	Yes	Yes	Yes	Supply and exhaust off
Room 14	741	76	39	29	Yes	Yes	Yes	Window open, milk cartons blocking exhaust
Room 16	696	77	40	26	Yes	Yes	Yes	Window open, fan
Room 17	608	75	39	18	Yes	Yes	Yes	Window open, accumulated dust on exhaust vent-obstructed by desk
Room 19	503	74	37	8	Yes	Yes	Yes	Chalk dust, exterior door/interior door open
Room 18	593	76	37	14	Yes	Yes	Yes	Plants on table near supply
Room 13	1010	77	41	20	Yes	Yes	Yes	Compost heap in front of fresh air supply, door open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Freedman Elementary School, Springfield, MA – September 26, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 1	729	76	40	24	Yes	Yes	Yes	Window open, cartons blocking supply
Room 3	541	73	39	18	Yes	Yes	Yes	Supply off, exterior door open, liquid paper, permanent magic marker
Room 4	572	73	38	19	Yes	Yes	Yes	Window and door open, supply blocked by shelf, paper blocking exhaust
Room 7	667	75	37	18	Yes	Yes	Yes	Window and door open, supply off-plants, stored materials obstructing exhaust, air freshener, rubber cement-hexane, permanent markers
Room 14	820	75	40	0	Yes	Yes	Yes	Window and door open, equipment blocking supply, milk crates blocking exhaust
Room 15	701	74	43	0	Yes	Yes	Yes	Leaking heat pipe(in univent-see picture), door open

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